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Some Cultural Experiments With Kenaf in Cuba[1]

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Kenaf, *Hibiscus cannabinus* L., is a fast-growing plant cultivated for its coarse bast fibers, which are similar to jute fibers, and can be put to the same uses—in making rugs, carpeting, twines, burlap, bagging, electric cables, oakum, and similar products. It is harvested in 100 to 150 days after planting, at which time it is 8 to 12 feet tall, with stalks about one-half inch in diameter. The fibers are borne in the bark and can be extracted either by machine or by retting.

The most extensive work on kenaf has been done in Cuba, where both Government and industrial organizations have been concerned with the efforts to make it a commercial crop. The experiments described in this publication, which are a part of these efforts, tested the effect of various cultural practices—planting date, age at harvest, distance between rows, method of seeding, and rate of seeding—on the yield and strength of fiber and on the yield of seed.

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[2] The authors were assisted by Ignacio Warner, Rafael Bedia, Pedro J. Pujals-Hernandez, Ciro J. Naranjo, and Arturo Pino, Cuban Ministry of Agriculture, and, in the biometrical analysis of the data, by Otis A. Pope, James G. Osborne, and Henry Hopp, U. S. Department of Agriculture.

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REVIEW OF LITERATURE

Wide differences in yields of fiber and seed have been reported in previous studies. For instance, yields of dry fiber have ranged from 60 to 6,245 pounds per acre (*1*, *2*, *4*, *6*, *7*, *8*, *11*, *13*)[3] though average yields in Cuba have been about 2,000 pounds. Cultural factors that have been found to cause these differences are the time of planting, age at harvest, and seeding procedures.

Crane, Acuña, and Alonso (*6*) found that the best time to plant for fiber in Cuba was at the beginning of the rainy season, in late April or early May. Plantings made at this time gave higher yields of both green matter and fiber, and a higher percent of fiber, than plantings made at later dates. Later plantings, however, showed less damage from nematodes. For production of seed, July plantings gave highest yields (*5*).

The optimum time to harvest for fiber has been variously expressed as plant age, plant height, and stage of flowering. None of these indexes, however, are either constant or equivalent. The growth habits of the plant, including fiber production, height growth, and flowering period, vary according to the date of planting and the favorableness of the growing season. An early planting may reach a height of 12 feet or more and mature before the days become short enough for much flowering. A late planting may not reach a height of more than 3 or 4 feet before flower production starts, but thereafter it may continue to grow somewhat and produce fiber.

The time of harvest influences the yield of fiber per acre, the quality of fiber (strength, fineness, luster, and so forth), and the proportion of fiber in fresh plants. Yields of fiber were found by Crane, Acuña, and Alonso (*6*) to increase up to at least 143 days. Fiber of highest quality, however, occurs at a time somewhat earlier (*1*, *4*, *12*). The proportion of dry fiber, because of maturation of the plants, continues to increase beyond the time of highest fiber yields. Highest proportion of fiber noted by Horst (*10*)—6.44 percent—was in plants that had reached seed maturity, at an age of 155 days.

Crane and Acuña (*5*) harvested kenaf for seed when the plants were mature and had shed their leaves.

Spacings used between the plants have varied, ranging for production of fiber, from 3 to 36 inches between rows and from 2 to 8 inches between plants in the row. In Cuba, Crane, Acuña, and Alonso (*6*), using 2-inch spacings in the row, obtained higher yields per acre as they decreased the distance between rows from 24 to 8 inches. They also observed that, as they increased the spacing, plants branched out more. In El Salvador, Watkins (*11*) noted that, with plants 2 inches apart in the row, a distance of 12 inches between rows resulted in the largest yields. For production of seed, Crane and Acuña (*5*) obtained highest seed yield when they spaced the hills at 20 by 12 inches—the closest spacing they tried in that experiment.

The method of sowing reported in almost all of the literature is row planting, but some unpublished information indicates that kenaf has also been sowed broadcast. Crane (*2*), however, reports that this method has not be recommended; it results in an uneven stand

[3] Italic numerals in parentheses refer to Literature Cited, p. 24.

of plants and a consequent lack of uniformity in the fiber produced.

Seeding rates (i. e., amount of seed per acre) used in these studies have also varied. For fiber production, they have ranged from as little as 13 pounds of seed per acre to as much as 58 (*1*, *2*, *3*, *7*, *9*, *10*). Wood (*13*) mentions 30 pounds per acre; and Crane, Acuña, and Alonso (*6*) found that, with rows 8 inches apart, 30 to 35 pounds per acre was the most productive rate. For seed production, rates have ranged from 0.8 pound per acre to 10 pounds (*1*).

MATERIALS AND METHODS

The experiments herein described were carried on at the Agricultural Experiment Station of the Ministry of Agriculture in Cuba, near Santiago de las Vegas, during 1946 and 1947. Test crops were planted on a Matanzas clay soil, with kenaf seed that had been grown by Crane and his associates in 1944 and 1945 (*9*).

Studies in 1946 tested the effects of planting date, age of plants at harvest, distance between rows, and stand density within rows. The experiments were laid out in a triple-split plot randomized block design, with three replications. Each block was divided into seven plots, which were planted at 4-week intervals beginning on April 16 and ending on October 1. However, adverse weather (fig. 1) in September and October so retarded the plantings in these months that they yielded no fiber of commercial quality. Data therefore were obtained from only the first five plots planted in each block. Each plot was split into 3 primary subplots of equal size, in which the rows were spaced 4, 8, and 16 inches apart, respectively. The primary subplots were each split into 2 equal secondary subplots, in which the seedlings were thinned to 5 and 10 plants per linear foot of row. These secondary subplots were further split into tertiary subplots to permit harvesting at periodic intervals. Harvesting was begun either 42 or 63 days after planting, depending on when the plants had reached an average height of about 3 feet. Harvests were made once every 3 weeks thereafter until it became evident that the fiber had begun to deteriorate.

In 1947 the experiments again tested the effects of planting date and age of plants at harvest, but modifications were made to study also the effects of seeding method and seeding rate. Again, a triple-split plot randomized block design was used. Each block consisted of three plots, which were planted on May 13, June 24, and August 5, respectively. Each plot was divided into two primary subplots of equal size, one sowed broadcast and the other in 8-inch drill rows (a grain drill was used that could be adjusted to plant either broadcast or in rows). The primary subplots were each split into five secondary subplots, in which the seed was sowed at 20, 30, 40, 50, and 60 pounds per acre. The secondary subplots were then further split into tertiary subplots for harvesting at 3-week intervals on the same schedule as in the previous years.

The tertiary subplots in each year were taken from randomized locations within the secondary subplots. In 1946 they consisted of 5 linear feet of one of the inner rows. In 1947 they consisted of areas 2 by 2½ feet in size. The total number of tertiary subplots was 450 in 1946 and 480 in 1947.

At harvest the plants of each tertiary subplot were cut at the ground line. Entire tops were tied in a bundle and weighed; values obtained are referred to in this publication as "field weight of plants." The bundles were then placed in a retting tank. When retting had been completed, the fiber was washed and then dried in an oven at approximately 90° F. until it failed to lose weight in consecutive weighings. Bundles approximately one-eighth inch in diameter were then taken for strength testing. They were cut 10 inches long, weighed, and given 10 twists in a tensile-strength machine with jaws set 3 inches apart center to center. The pounds of stress at the breaking point was divided by the weight in grams of each 10-inch bundle. The resultant value is referred to in this report as the strength index. The values given are averages of 25 breaks.

In both years the seed was harvested. Capsules when dry were picked by hand, hand-threshed, and cleaned. Seeds were dried by the same method as that used for fibers. In 1947 the seed was harvested by secondary subplots and weighed, in order to determine the effects of the experimental variables on seed yield.

Data on the field weight of plants, percent of dry fiber in the fresh plants, total yield and strength of dry fiber, and, in 1947, yield of seed were obtained.

Statements herein about significance are based on statistical analysis of data according to standard procedure for experiments of this design.

CLIMATIC DATA

The test period in 1946 was characterized by drought in July, August, and October (table 1). During the test period in 1947, however, the rainfall was rather evenly distributed (table 2). Figure 1, which compares the monthly precipitation in both years with the monthly average during the period 1934–48, shows that the precipitation in July and August of 1946 was far below the 15-year average although the October precipitation was apparently rather characteristic of the longer term trend.

RESULTS

Growing Kenaf for Fiber

YIELD OF DRY FIBER PER ACRE

The yields of fiber per acre varied in the 450 tertiary subplots in 1946 from a minimum of 130 pounds to a maximum of 5,250 pounds; and in the 480 tertiary subplots in 1947 from a minimum of 60 pounds to a maximum of 5,780 pounds.

Date of Planting and Age of Plants at Harvest.—In 1946 the June planting produced significantly higher yields of fiber per acre than plantings in other months; in 1947 the May and June plantings were almost equal, with May eventually leading slightly as older

TABLE 1.—*Daily precipitation at the Agricultural Experiment Station, Santiago de las Vegas, Cuba, by months, 1946*

[In inches]

Day of month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1			0. 60	0. 12	0. 41				0. 89	0. 64		0. 20
2									1. 42	. 33		
3									. 20	. 49		. 83
4						0. 87			. 17	. 21		. 51
5									1. 28	. 67		
6								0. 51	1. 71	1. 50		
7									. 08	1. 36		
8						. 88			. 16			
9						. 40	0. 42		. 36			
10					. 33	. 35			. 17			
11					. 47	2. 91			. 71			
12						. 45	1. 02	. 39	1. 22			
13					. 60	1. 38			. 24			
14		0. 67			. 12	3. 23				. 24		
15		. 08			1. 10	. 16		. 95				. 59
16				. 12		. 22						
17				. 22		2. 64		. 20				
18									. 94			
19			. 24			. 24		1. 38				
20						. 31			. 24			
21		1. 65			1. 08		. 28		. 22			
22		1. 32		1. 71		. 36						
23						. 41			. 24			
24	0. 48				. 37							
25					. 71	. 25						
26					. 52						. 87	. 16
27											. 08	
28		. 31	. 20								. 75	
29					. 45	2. 34	. 51	. 94	. 12			
30					. 83	. 29		. 55	. 39			
31					. 57							
Total	. 48	4. 03	1. 04	2. 17	7. 56	17. 69	2. 13	4. 92	10. 76	5. 44	1. 60	2. 29

TABLE 2.—*Daily precipitation at the Agricultural Experiment Station, Santiago de las Vegas, Cuba, by months, 1947*

[In inches]

Day of month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1								0. 08			0. 03	0. 12
2			1. 34							0. 34		. 04
3										1. 05		
4		0. 58					0. 05			. 73		
5	0. 55					0. 10	1. 11	. 87	2. 01			
6				0. 83		. 30	. 55		. 40			
7						. 30	. 41					
8			. 71	. 03	3. 38	. 30	1. 71	. 78		1. 01	. 71	
9					1. 18	. 48		. 56	. 61	2. 01		
10				. 41	. 26	. 29	. 95	. 44		2. 10		
11			. 47	. 26	. 47	. 17	. 66	. 48		. 36		
12			. 20		. 98	1. 05		. 38				
13						2. 06			. 23			
14		. 32				. 40	. 06					
15		. 12						. 51				
16		. 20	1. 12			. 05		. 32				
17								. 10	. 16	. 03		
18					2. 01		1. 14		3. 84			
19				. 04			. 95					
20			. 50			. 15	. 34		2. 05			
21				. 56		. 05			. 34	. 53		
22		. 04				. 06		. 42				. 08
23					. 83		. 40	. 12	. 11			
24				. 08	. 88	. 05		. 14	1. 91	. 18		
25		. 24		. 24	1. 00		. 42	. 28	3. 93			
26	. 46				. 89	. 14	. 20					
27	. 67				. 99	. 05	. 16	. 26	. 38			
28						. 08		. 78			. 59	
29					. 40		. 35		. 48		1. 38	
30						. 10	. 12	. 20	. 64	2. 53	. 39	
31			. 51		. 42		. 73					
Total	1. 68	1. 50	4. 85	2. 44	13. 69	6. 18	10. 31	6. 72	17. 09	10. 87	3. 10	. 24

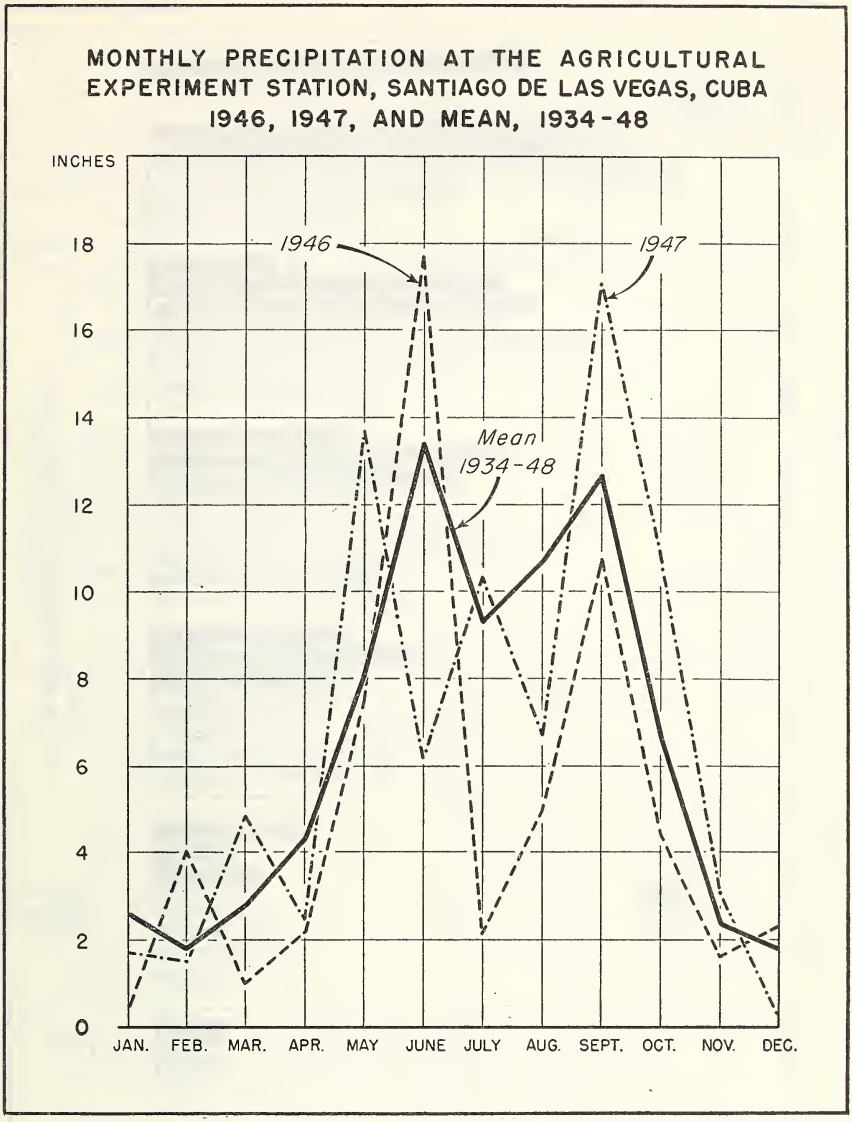

Figure 1.

plants were harvested (fig. 2). This effect of planting date, which did not become significant until 84-day-old plants were harvested, became increasingly obvious with each successive harvest.

Highest average yields per acre were obtained from plantings 147 days old: 3,602 pounds from the June planting in 1946 and 2,472 pounds from the May planting in 1947. Plantings in July and August succumbed to the normal dry season in the fall, and the last harvests taken from them were at 126 days for the plantings in July 1946 and August 1947, and at 105 days for the planting in August

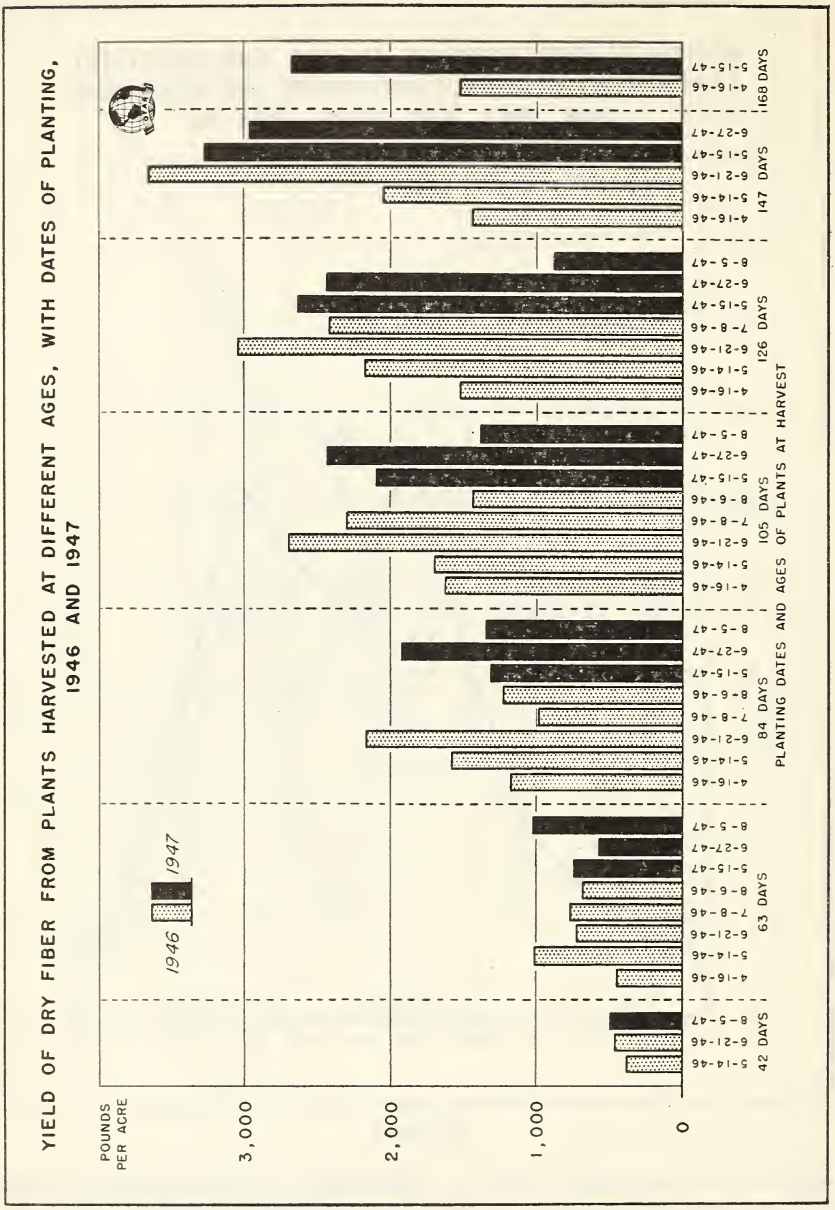
YIELD OF DRY FIBER FROM PLANTS HARVESTED AT DIFFERENT AGES, WITH DATES OF PLANTING, 1946 AND 1947
POUNDS PER ACRE
3,000
2,000
1,000
0
1946
1947
5-14-46
6-21-46
8-5-47
42 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
63 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
84 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
105 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
126 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
147 DAYS
4-16-46
5-14-46
6-21-46
5-1-47
6-27-47
168 DAYS
4-16-46
5-15-47
PLANTING DATES AND AGES OF PLANTS AT HARVEST

Figure 2.

1946. Highest yields of fiber from plantings in these 2 months were at the last harvestable ages (table 3).

It is interesting to note the rapidity with which the fiber was produced in the plants. By the end of 42 days the June planting in 1946 had produced 471 pounds of dry fiber per acre, a little more than 11 pounds per day. But after 147 days the plants had produced 3,603 pounds, or 24.5 pounds per day from the time of planting and 29.8 pounds per day between the ages of 42 and 147 days.

TABLE 3.—*Date at which maximum yield of fiber was obtained from each planting in 1946 and 1947, amount of fiber, and age at harvest*

Planting date	Harvest date	Yield per acre	Age at harvest
1946:		*Pounds*	*Days*
Apr. 16	July 30	1, 617	105
May 14	Sept. 17	2, 193	126
June 21	Nov. 16	3, 603	147
July 8	Nov. 13	2, 427	126
Aug. 6	Nov. 19	1, 454	105
1947:			
May 15	Oct. 7	3, 296	147
June 27	Nov. 17	2, 956	147
Aug. 5	Nov. 17	1, 379	105

TABLE 4.—*Yield of dry kenaf fiber in 1946: Effect of distance between rows and density of stand within rows*

Distance between rows	5 plants per foot	10 plants per foot	Mean
	Pounds per acre	*Pounds per acre*	*Pounds per acre*
4 inches	1, 734	1, 852	1, 793
8 inches	1, 465	1, 537	1, 501
16 inches	1, 445	1, 410	1, 428
Mean	1, 548	1, 600	1, 574

TABLE 5.—*Yield of dry kenaf fiber in 1946: Effect of distance between rows as influenced by date of planting*

Planting date	4 inches between rows	8 and 16 inches between rows
	Pounds per acre	*Pounds per acre*
Apr. 16, May 14	1, 351	1, 415
June 21, July 8, Aug. 6	2, 202	1, 511
Weighted mean	1, 793	1, 464

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TABLE 6.—*Yield of dry kenaf fiber in 1947: Effect of seeding method and seeding rate*

Pounds of seed per acre	Broadcast	Drilled	Mean
	Pounds per acre	*Pounds per acre*	*Pounds per acre*
20	1, 816	1, 907	1, 862
30	1, 861	1, 867	1, 864
40	1, 580	1, 698	1, 643
50	1, 690	1, 762	1, 724
60	1, 757	1, 670	1, 714
Mean	1, 741	1, 781	1, 761

SPACING.—Effect of distance between rows on the yield of dry fiber per acre was tested only in 1946. The rows spaced closest together consistently produced the highest yields; and, as the distance between rows was increased, the yields per acre decreased (table 4). Although rows 16 inches apart yielded less fiber per acre than those 8 inches apart, the difference between those two widths was not significant; nor was there any significant difference between spacing 5 and 10 plants per foot within the row. Advantage of the 4-inch distance between rows did not appear in April and May plantings; but in the June, July, and August plantings the yield from rows thus spaced was 50 percent higher than from rows 8 and 16 inches apart (table 5).

METHOD AND RATE OF SEEDING.—When seeding methods and rates were studied in 1947 to determine the effect they had on the production of dry fiber, it was found that it made no significant difference whether the seeds were sowed broadcast or planted in drill rows, but that yields were higher for both methods when 20 and 30 pounds of seed were used per acre than when 40, 50, and 60 pounds were used (table 6). In other words, in 1947 an increase in the planting density resulted in smaller yields of fiber; but in 1947 an increase in the planting density—achieved by spacing the rows close together—resulted in greater yields, although the association was apparently influenced by planting date.

This difference between the 2 years appeared to be related to the weather. In 1946 there was a marked dry period in July and August; total precipitation in those months—only 7.05 inches—was 12.7 inches less than the average for the 15-year period 1934–48. Competition among the plants for the moisture was strong, and self-thinning was most severe at the close spacings, resulting eventually in less of a stand there than at the wide spacings. Especially affected were the late plantings, which had been subjected to drought while the plants were very young. When the rains came in September, the acceleration of growth was greatest in the most severely thinned plantings.

In 1947, however, there was no drought, and growth continued normally. At the time of the early harvests, competition between plants was not strong and different rates of seeding showed no significant effect on the yield of fiber (table 7). Later harvests, on the other hand, from the age of 126 days and on, showed that the higher seeding rates had had a general stunting effect and that only at the lower rates had plants continued to grow rapidly.

TABLE 7.—*Yield of dry kenaf fiber in 1947: Effect of seeding rate as influenced by age of plants at harvest*

Age of plants at harvest	20 pounds per acre	30 pounds per acre	40 pounds per acre	50 pounds per acre	60 pounds per acre	Mean, all rates
	Pounds per acre	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*
42 days	365	499	518	634	461	495
63 days	710	902	614	787	854	772
84 days	1, 498	1, 440	1, 478	1, 555	1, 651	1, 524
105 days	2, 112	1, 882	1, 766	1, 978	2, 151	1, 978
126 days	2, 151	2, 131	1, 709	1, 939	1, 978	1, 982
147 days	3, 571	3, 360	2, 919	3, 034	2, 727	3, 122
168 days	2, 880	3, 533	3, 226	2, 112	1, 632	2, 677
Mean	1, 862	1, 864	1, 643	1, 724	1, 714	1, 761

It appears, therefore, that lighter seeding rates are to be preferred. They are no more advantageous if the plants are harvested early or if no drought occurs to thin the plants. But if the plants are harvested late, or if drought occurs, light seeding rates and wide spacings are best.

FIELD WEIGHT OF PLANTS

DATE OF PLANTING AND AGE OF PLANTS AT HARVEST.—Field weight of kenaf plants was affected by the various cultural factors in much the same way as yield of dry fiber was. Field weight, like fiber yield, was greatest from the June plantings—59,000 pounds per acre in 1946 and 70,000 pounds in 1947—but was greatest in both years when the plantings were harvested at an age of 105 days, earlier than the best age for yield of fiber (cf. figs. 2 and 3). After 105 days the June plantings, which at that age were harvested in the first part of October, decreased in weight, losing moisture and leaves as they matured. In fact, all plantings except the late ones began to decline at a date near October 1; August plantings began to decline in late October and early November.

SPACING.—As spacing between rows was reduced in 1946 from 16 inches to 8 and 4 inches, the field weight of green plants progressively

TABLE 8.—*Field weight of kenaf plants in 1946: Effect of distance between rows and density of stand within rows*

Distance between rows	5 plants per foot	10 plants per foot	Mean
	1,000 pounds per acre	*1,000 pounds per acre*	*1,000 pounds per acre*
4 inches	39. 3	41. 2	40. 3
8 inches	33. 0	32. 7	32. 8
16 inches	29. 6	29. 8	29. 7
Mean	34. 0	34. 6	34. 3

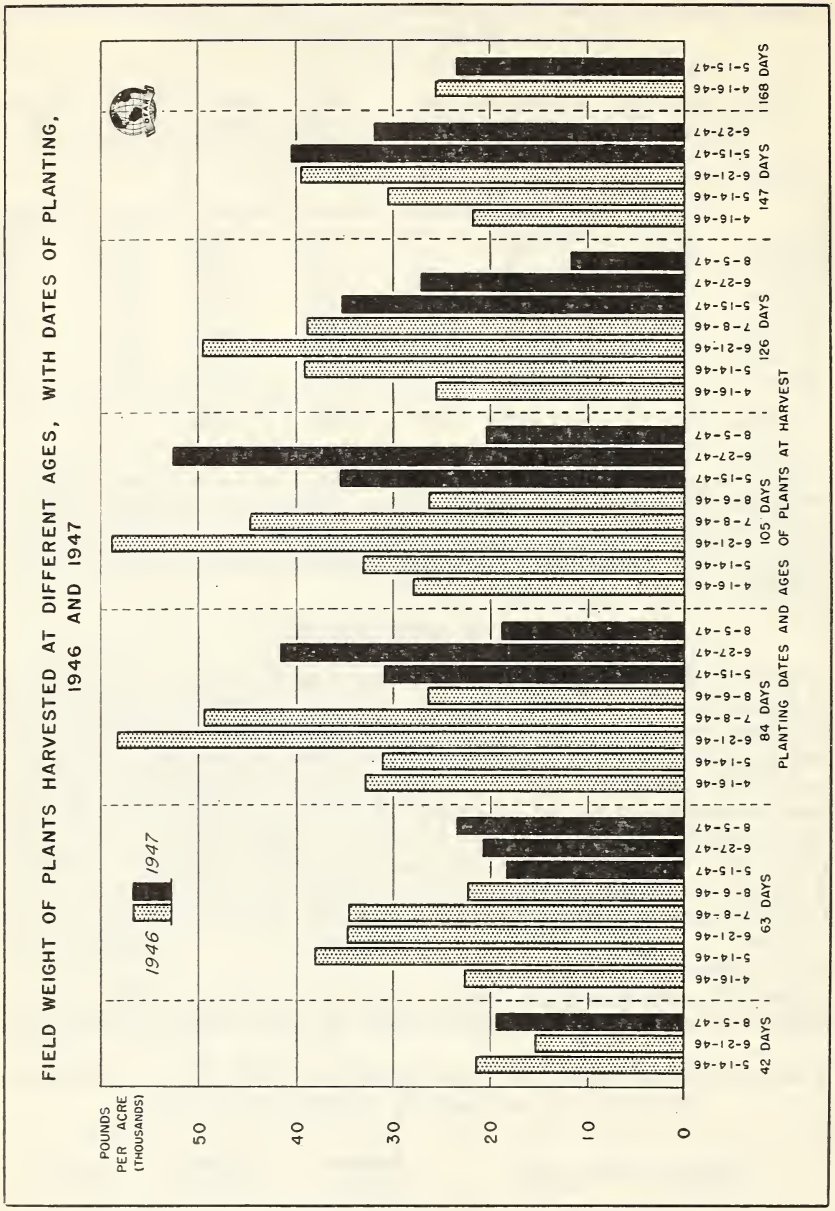
FIELD WEIGHT OF PLANTS HARVESTED AT DIFFERENT AGES, WITH DATES OF PLANTING, 1946 AND 1947
POUNDS PER ACRE (THOUSANDS)
0
10
20
30
40
50
1946
1947
5-14-46
6-21-46
8-5-47
42 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
63 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
84 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
105 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
5-15-47
6-27-47
8-5-47
126 DAYS
4-16-46
5-14-46
6-21-46
5-15-47
6-27-47
8-5-47
147 DAYS
4-16-46
4-16-46
5-15-47
168 DAYS
PLANTING DATES AND AGES OF PLANTS AT HARVEST

Figure 3.

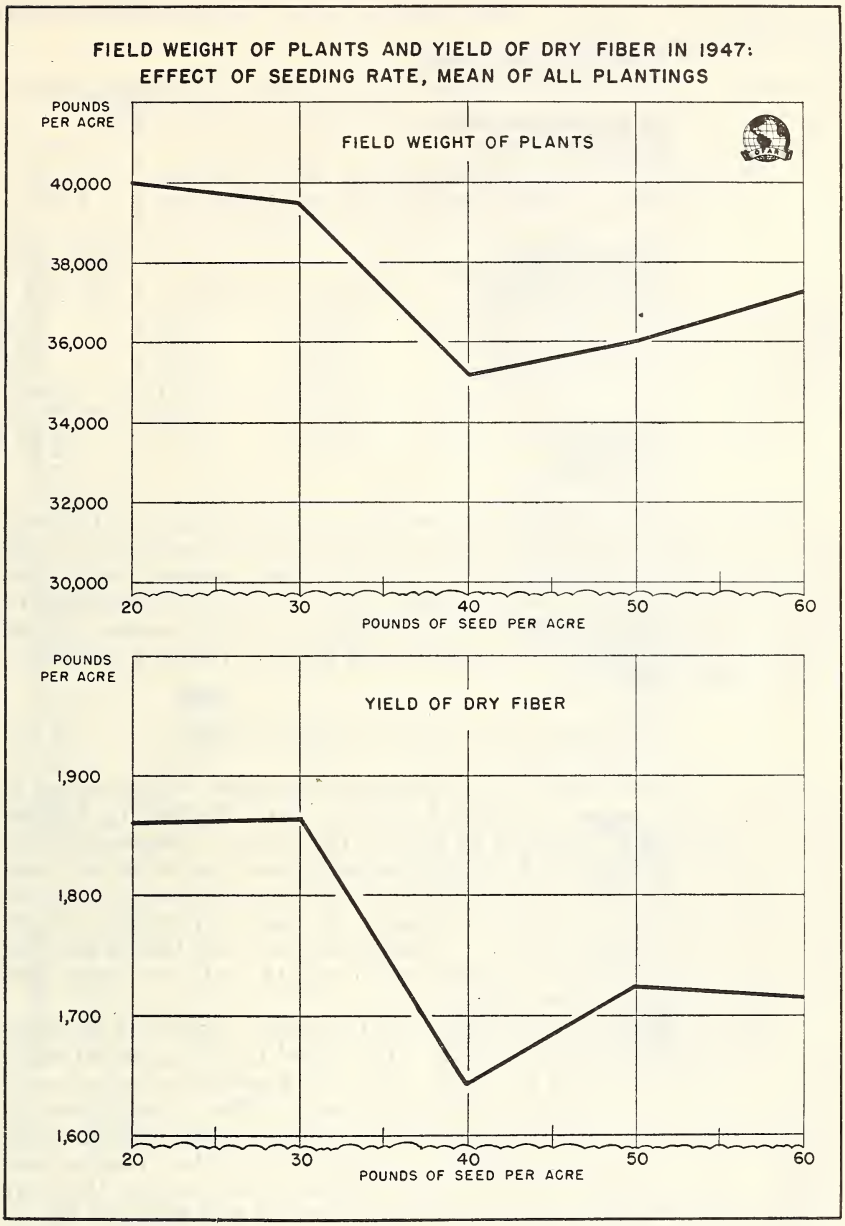

Figure 4.

increased, though the difference between 8- and 4-inch widths was not significant (table 8). Neither was there a significant difference between spacing plants within the row at 5 and 10 per foot.

The higher field weights when rows were spaced close together were clearly evident only in plantings made in June, July, and August.

In earlier plantings the difference in effect of various distances was not significant (table 9).

TABLE 9.—*Field weight of kenaf plants in 1946: Effect of distance between rows as influenced by date of planting*

Planting date	4 inches between rows	8 inches between rows	16 inches between rows	Mean
	1,000 pounds per acre	*1,000 pounds per acre*	*1,000 pounds per acre*	*1,000 pounds per acre*
April 16	27. 0	26. 5	28. 1	27. 2
May 14	32. 8	34. 6	29. 3	32. 3
June 21	54. 2	39. 2	35. 2	42. 8
July 8	51. 4	39. 2	35. 1	41. 9
August 6	39. 2	20. 7	15. 1	25. 0
Mean	40. 3	32. 8	29. 7	34. 3

METHOD AND RATE OF SEEDING.—Field weight of plants in 1947 was about the same in plantings that had been sowed broadcast as in the ones that had been planted in 8-inch drill rows; average weight for each method was 37,600 pounds (table 10). Varying the seeding rate, however, affected the weight significantly, in much the same way as it affected the yield of fiber, the 20- and 30-pound rates resulting in larger yields (fig. 4).

PERCENT OF DRY FIBER IN FRESH PLANTS

DATE OF PLANTING AND AGE OF PLANTS AT HARVEST.—Comparison of harvests at the same age showed that the date of planting had no marked effect on the percent of fiber in the plants. Generally, however, each planting showed a higher proportion of fiber with each consecutive harvest, increasing steadily from about 2 percent in plants harvested at 42 days of age to an average of nearly 10 percent in plants harvested at 147 days (fig. 5). Young plants not only lacked fiber but also had a high moisture content; older plants contained more fiber and had a lower moisture content.

In 1946 the percent of dry fiber was noticeably influenced by alternate periods of drought and rain. The April planting lost so much moisture during the dry period in July and August that when, early in September, it reached the 147-day harvest, its fiber content was up to 17 percent. But before the next harvest of the planting, the drought had been broken; live plants put out new growth and dead ones became sodden. As a result, at the time of the next harvest—at 168 days of age—the percentage of fiber for this planting had fallen to 6.5.

SPACING.—Whether plants were thinned to 5 or 10 per foot within the rows had no significant effect on the proportion of dry fiber in kenaf plants (table 11). The distance between rows, however, did influence the proportion of fiber. The rows 16 inches apart showed a higher percent of fiber than rows 4 and 8 inches apart, but this difference did not appear until plants were 126 days old or older (table 12). The plants in rows 16 inches apart matured sooner than

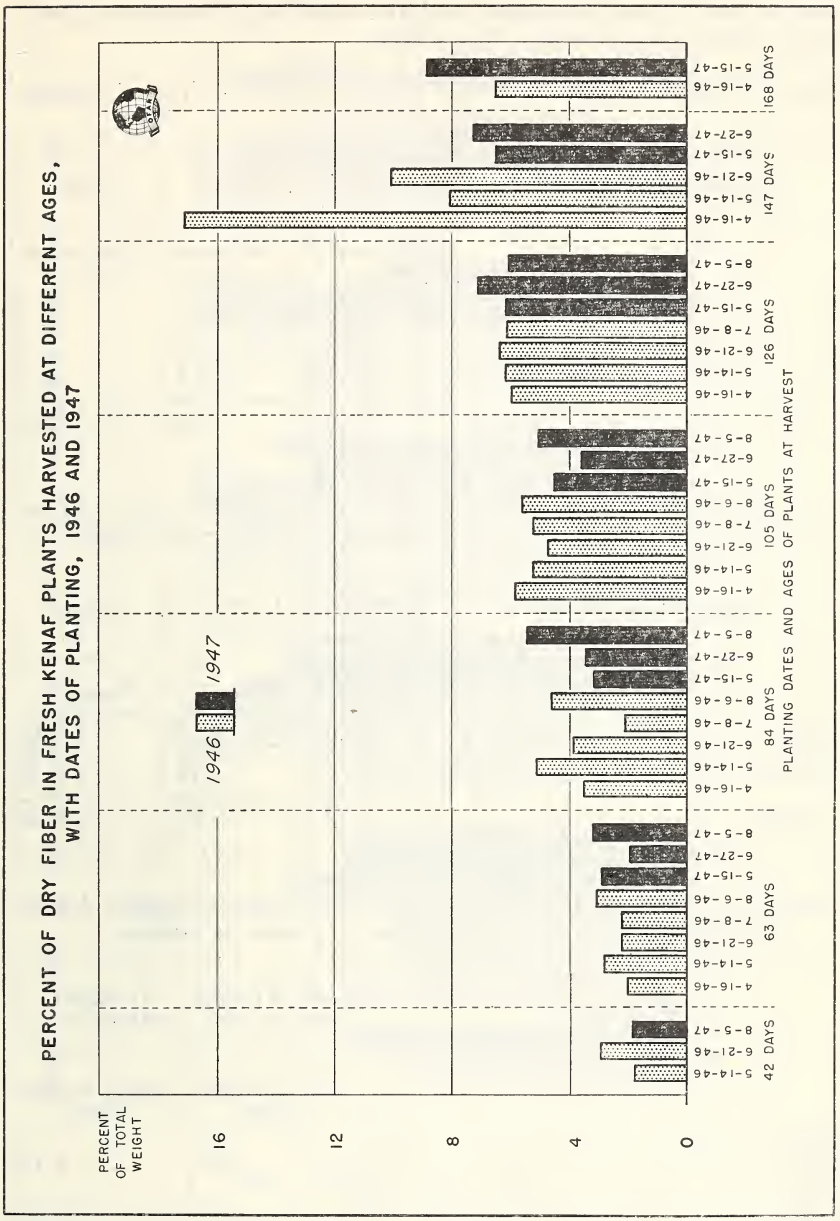
PERCENT OF DRY FIBER IN FRESH KENAF PLANTS HARVESTED AT DIFFERENT AGES, WITH DATES OF PLANTING, 1946 AND 1947
PERCENT OF TOTAL WEIGHT
16
12
8
4
0
1946
1947
42 DAYS
63 DAYS
84 DAYS
105 DAYS
126 DAYS
147 DAYS
168 DAYS
PLANTING DATES AND AGES OF PLANTS AT HARVEST
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
4-16-46

Figure 5.

those in rows closer together; and the resulting decrease in fresh weight raised the percentage of dry fiber.

TABLE 10.—*Field weight of kenaf plants in 1947: Effect of seeding method and seeding rate*

Pounds of seed per acre	Broadcast	Drilled	Mean
	1,000 pounds per acre	*1,000 pounds per acre*	*1,000 pounds per acre*
20	39. 5	40. 5	40. 0
30	40. 3	38. 7	39. 5
40	32. 9	37. 5	35. 2
50	36. 9	35. 2	36. 0
60	38. 5	36. 1	37. 3
Mean	37. 6	37. 6	37. 6

TABLE 11.—*Percent of dry fiber in fresh kenaf plants in 1946: Effect of distance between rows and density of stand within rows*

Distance between rows	5 plants per foot	10 plants per foot	Mean
	Percent of total weight	*Percent of total weight*	*Percent of total weight*
4 inches	5. 00	5. 05	5. 02
8 inches	4. 55	4. 93	4. 74
16 inches	5. 82	5. 78	5. 80
Mean	5. 12	5. 26	4. 88

TABLE 12.—*Percent of dry fiber in fresh kenaf plants in 1946: Effect of distance between rows and age of plants at harvest*

Age at harvest	4 and 8 inches between rows	16 inches between rows
	Percent of total weight	*Percent of total weight*
42 days, 63 days, 84 days, 105 days	3. 73	3. 70
126 days, 147 days, 168 days	7. 34	10. 28
Weighted mean	4. 88	5. 80

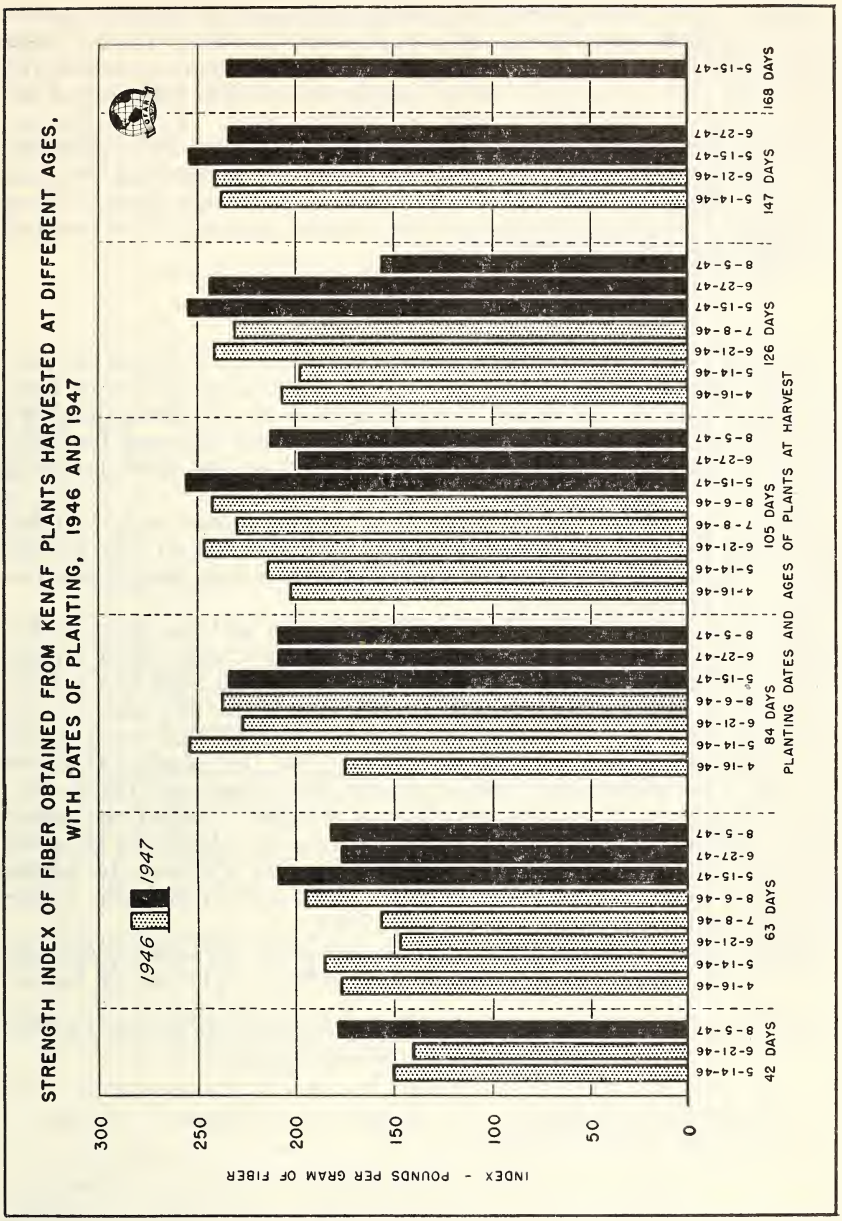
STRENGTH INDEX OF FIBER OBTAINED FROM KENAF PLANTS HARVESTED AT DIFFERENT AGES, WITH DATES OF PLANTING, 1946 AND 1947
1946
1947
INDEX - POUNDS PER GRAM OF FIBER
300
250
200
150
100
50
0
PLANTING DATES AND AGES OF PLANTS AT HARVEST
42 DAYS
5-14-46
6-21-46
8-5-47
63 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
84 DAYS
4-16-46
5-14-46
6-21-46
8-6-46
5-15-47
6-27-47
8-5-47
105 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
8-6-46
5-15-47
6-27-47
8-5-47
126 DAYS
4-16-46
5-14-46
6-21-46
7-8-46
5-15-47
6-27-47
8-5-47
147 DAYS
5-14-46
6-21-46
5-15-47
6-27-47
168 DAYS
5-15-47

Figure 6.

Method and Rate of Seeding.—Whether seeds were sown broadcast or in drill rows, the average percent of dry fiber in the fresh plants was about the same (table 13). But variations in the amount of seed planted per acre did affect the percent of fiber: at 50- and 60-pound rates it was higher than at lighter rates. This difference occurred only in harvests of plants 147 and 168 days old (table 14) and was due to the greater amount of dead, dry plants that resulted from self-thinning where plants had been most thickly sown. These dead plants had decreased in moisture content, a change that resulted in a higher percentage of dry fiber.

STRENGTH OF DRY FIBER

Date of Planting and Age of Plants at Harvest.—When the various plantings were compared at the same harvest age, no consistent trend was noted in the effect of planting date on the strength of the fiber (fig. 6). In both years, however, highest strength was found in fiber from the May plantings, in 1946 at a harvest age of 84 days and in 1947 at an age of 105 days.

Fiber was weakest when taken from young plants and, in most plantings, grew significantly stronger with age up to 105 or 126 days. Thereafter the strength decreased somewhat though the decrease was generally slight.

Spacing.—The density of plants in the rows and the distance between the rows had only a small, although significant, effect on the tensile strength of fiber. The strength index of the fiber was 5 units less for 5 plants to the foot than it was for 10 plants, and was 10 units less for 4-inch rows than it was for 8- and 16-inch rows (table 15). Not only were these differences small but the effect of distance between rows held only in the April and May plantings (table 16). The plantings in June, July, and August showed no significant effect due to distance between rows. In the two earlier plantings, the self-thinning associated with drought, resulted in few plants in the 4-inch rows than in the 8-inch rows; thus the data signify that the closer spacings resulted in somewhat stronger fiber.

Method and Rate of Seeding.—In the May and June plantings in 1947, sowing in drill rows resulted in fiber of significantly higher

Table 13.—*Percent of dry fiber in fresh kenaf plants in 1947: Effect of seeding method and seeding rate*

Pounds of seed per acre	Broadcast	Drilled	Mean
	Percent of total weight	*Percent of total weight*	*Percent of total weight*
20	4. 6	4. 7	4. 6
30	4. 7	4. 8	4. 8
40	4. 8	4. 7	4. 7
50	4. 7	5. 3	5. 0
60	5. 0	4. 9	5. 0
Mean	4. 8	4. 9	4. 8

average strength than sowing broadcast; and the 50- and 60-pound rates in higher strength than the 20-, 30-, and 40-pound rates (table 17). But the August planting showed no significant difference due to either method or rate of seeding.

TABLE 14.—*Percent of dry fiber in fresh kenaf plants in 1947: Effect of seeding rate as influenced by age of plants at harvest*

Age of plants at harvest	20, 30, and 40 pounds of seed per acre	50 and 60 pounds of seed per acre
	Percent of total weight	*Percent of total weight*
42 days		
63 days		
84 days	3. 4	3. 4
105 days		
126 days		
147 days	7. 2	8. 1
168 days		
Weighted mean	4. 7	5. 0

TABLE 15.—*Strength index of kenaf fiber in 1946: Effect of distance between rows and density of stand within rows*

Distance between rows	5 plants per foot	10 plants per foot	Mean
4 inches	195	206	200
8 inches	208	210	209
16 inches	209	211	210
Mean	204	209	206

TABLE 16.—*Strength index of kenaf fiber in 1946: Effect of distance between rows as influenced by date of planting*

Planting date	4 inches between rows	8 and 16 inches between rows
April 16		
May 14	187	207
June 21		
July 8	211	212
August 6		
Weighted mean	200	210

TABLE 17.—*Strength index of kenaf fiber in 1947: Effect of method and rate of seeding as influenced by month of planting*

Seeding method and rate	May and June	August
Seeding method:		
Broadcast	220	189
Drilled	236	186
Seeding rate:		
20 pounds	221	187
30 pounds		
40 pounds		
50 pounds	237	187
60 pounds		

These 1947 tests agree approximately, then, with the 1946 tests on spacing: Close spacing resulted in fiber of greater strength from the April and May plantings of 1946; whereas no significant difference in fiber strength due to spacing was found in the later plantings, those in June, July, and August of 1946 and in August of 1947. Likewise, drilling the seed resulted in stronger fiber than broadcasting the same amount, but only in the earlier plantings.

GROWING KENAF FOR SEED

DATE OF PLANTING

Seed production was measured only in the 1947 plantings. Highest average yield of seed for any date was 519 pounds per acre from the June planting, and the lowest was 343 pounds from the August planting (table 18).

METHOD AND RATE OF SEEDING

Seed production declined as the rate of sowing increased from 20 to 60 pounds per acre. This was true for all three dates of planting (table 18) and for both broadcast and drilled sowing (table 19).

TABLE 18.—*Yield of kenaf seed in 1947: Effect of seeding rate as influenced by date of planting*

Planting date	20 pounds of seed per acre	30 pounds of seed per acre	40 pounds of seed per acre	50 pounds of seed per acre	60 pounds of seed per acre	Mean, all rates
	Pounds per acre	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*	*Pounds per acre*
May 15	522	592	442	336	304	439
June 27	829	327	439	589	410	519
August 5	375	291	397	339	311	343
Mean	575	403	426	421	341	433

At all seeding rates but one—40 pounds of seed per acre—broadcast planting gave significantly higher yields of seed than drill planting.

TABLE 19.—*Yield of kenaf seed in 1947: Effect of seeding method and seeding rate*

Pounds of seed per acre	Broadcast	Drilled	Mean
	Pounds per acre	*Pounds per acre*	*Pounds per acre*
20	655	495	575
30	429	377	403
40	391	461	426
50	551	292	421
60	454	228	341
Mean	496	371	433

DISCUSSION

PRODUCTION OF FIBER

This experiment indicates that there is an optimum time for planting and harvesting kenaf for fiber, but considerations of commercial production necessitates modifications in actual practice. All the acreage should not be planted at one time, even to take advantage of these optimums, because doing so would not permit efficient use of equipment and labor. If one should assume that a profitable yield of kenaf fiber is, for example, 1,000 pounds per acre, then an analysis of harvests yielding that much or more will make it possible to determine when the plantings should begin and how long they should continue.

In 1946, the first harvest of 1,000 pounds or more of dry fiber per acre occurred on July 9, when the April planting was harvested at an age of 84 days and yielded 1,180 pounds; the last occurred on November 15, when the June planting was harvested at an age of 147 days and yielded 3,603 pounds (table 20). In 1947 the first harvest of that size was obtained from the May planting on August 7, at an age of 84 days, with a yield of 1,303 pounds; and harvests greater than 1,000 pounds of fiber per acre continued through November 17, when the June and August plantings yielded 2,956 pounds and 1,379 pounds respectively, at the ages of 147 and 105 days. Thus, one could expect the harvest season to begin about July 1 and continue to mid-November if first plantings were made in mid-April and continued at intervals through mid-August.

Since drought greatly retarded the formation of fiber in kenaf plants, and might even stop it, irrigation where it is economically feasible could be used to increase fiber yields. Kenaf can be grown in the dry season with the aid of irrigation, but data are not available on the yields of fiber.

TABLE 20.—*Dates on which plantings reached the harvest ages at which they yielded at least 1,000 pounds of fiber per acre, 1946 and 1947*

Date of planting	63 days	84 days	105 days	126 days	147 days	168 days
1946:						
April 16	----------	July 9	July 30	Aug. 20	Sept. 17	Oct. 1
May 14	July 16	Aug. 6	Aug. 27	Sept. 17	Oct. 7	--------
June 21	----------	Sept. 17	Oct. 5	Oct. 25	Nov. 16	--------
July 8	----------	Oct. 3	Oct. 22	Nov. 13	----------	--------
August 6	----------	Oct. 29	Nov. 19	----------	----------	--------
1947:						
May 15	----------	Aug. 7	Aug. 28	Sept. 23	Oct. 7	Oct. 30
June 27	----------	Sept. 23	Oct. 9	Oct. 31	Nov. 17	--------
August 5	Oct. 8	Oct. 28	Nov. 17	----------	----------	--------

PRODUCTION OF SEED

Highest yields of seed were taken from the June plantings but, by the time seeds were dry enough to be harvested, the plants were 8 to 12 feet tall; and in some subplots the mortality of plants was very high before the seeds were mature. Plants from later plantings were not so tall and produced seed nearer the ground. If the stalks had been cut near the ground line, there would have been too much straw to be put efficiently through the threshing machine now available and the plants would have been too tall for a combine. As a result, either the June-sown plants would have had to be topped for threshing, or plants would have had to be sown at a later date so that, when they were ready for seed harvest, they still would have been small enough for the available machinery.

The straw stacks from threshing consist of approximately 20 percent fiber, on a field-dry basis. Clean fiber recovered from these stacks has commercial value.

SUMMARY

PRODUCTION OF FIBER

PLANTING DATE.—Highest yield of fiber per acre came from the June planting in 1946. In 1947 the highest yield came from the May planting, but the June planting was a close second.

Effect of planting date on field weight of plants was much the same as it was on fiber yield, but June plantings led in both years.

The proportion of dry fiber in the fresh plants, however, was not influenced by date of planting. Nor was the strength of the fiber influenced by the date of planting, though fiber from the May planting was strongest in both years, in 1946 when plants were harvested at 84 days and in 1947 when they were harvested at 105 days.

Age at Harvest.—Apparently the best time for harvesting kenaf for fiber ranges from 105 to 147 days, depending on date of planting and weather. Three plantings gave their highest yield of fiber at 147 days; three others, at 105 days; and the other two, at 126 days. The rate at which plants produced fiber increased very rapidly as they grew older, up to 147 days.

Field weight of plants was highest in harvests at 105 days.

Percent of dry fiber content in fresh plants changed very markedly as plants grew older, increasing from about 2 percent in plants harvested at 42 days to about 10 percent in those harvested at 147 days.

Weakest fiber was produced in the earliest harvest. Tensile strength of fiber increased significantly in most plantings with each subsequent harvest, up to 105 or 126 days, and thereafter remained about the same.

Spacing.—Distance between plants within rows—5 or 10 plants to the foot—had little effect on the yield of fiber, on the field weight of plants, or on the percent of dry fiber in the plants. On the tensile strength of fiber, however, spacing the plants at 10 to the foot showed a small though significant advantage.

Distance between the rows was an important factor. Closest rows consistently produced both highest yields of fiber per acre and highest field weight of plants, though the difference between 8- and 4-inch widths was not significant. The advantage of planting rows close together was evident only in June, July, and August plantings.

The percent of dry fiber, on the other hand, was higher when distance between rows was increased from 4 and 8 inches to 16 inches, although this difference was not apparent until plants were harvested at an age of 126 days or more.

The 8- and 16-inch distances between rows were best for producing fiber with high tensile strength, but the advantage was slight, held only for the early plantings, and was complicated by the effect of drought, which caused a more open stand at the closer row spacing. In the June planting, the one that gave the highest yield of fiber per acre, there was no significant difference.

Seeding Method and Rate.—Method of planting—broadcast or in drill rows—made little difference in yield of fiber, in field weight of plants, or in percent of dry fiber in plants, and only a slight difference in tensile strength of the fiber. The difference in tensile strength, moreover, was evident only in the earlier plantings.

Lighter seeding rates, 20 or 30 pounds per acre, gave higher fiber yields for the later harvests, which were the ones that produced the most fiber. Lighter seeding rates resulted also in higher field weight of plants.

Production of Seed

The June planting, the 20-pound seeding rate, and the broadcast method of planting resulted in the highest yield of seed.

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